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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 10/043,225 | 01/14/2002 | Masamoto Tago | Q67964 | 4956 |

23373 7590 03/10/2004

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| **ART UNIT** | **PAPER NUMBER** |
| 2811 | |

DATE MAILED: 03/10/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

| Office Action Summary | Application No. | Applicant(s) |
|---|---|---|
| | 10/043,225 | TAGO ET AL. |
| | Examiner | Art Unit |
| | Nitin Parekh | 2811 |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☒ Responsive to communication(s) filed on *08 December 2003*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4)☒ Claim(s) *1-158* is/are pending in the application.

4a) Of the above claim(s) *57-157* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-56 and 158* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

**Application Papers**

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *21 April 2003* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. §§ 119 and 120**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

13)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application) since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

a) ☐ The translation of the foreign language provisional application has been received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121 since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

**Attachment(s)**

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 9 .

4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: .

## DETAILED ACTION

### *Information Disclosure Statement*

1. The Information Disclosure Statements filed on 03-06-02 and 11/22/03 have been considered.

### *Claim Rejections - 35 USC § 103*

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

6. Claims 1, 3, 5, 7, 9, 11, 21, 22, 25, 26, 29-33, 39-43, 49, 50, 53 and 54 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046) in view of Chan et al. (US Pat. 5471092).

Regarding claim 1, Marlin discloses a semiconductor device (100 in Fig. 5) having a solder bump (310 in Fig. 5) formed of an alloy solder including tin-silver (SnAg- Col. 2, line 19), the Sn and Ag being a first and second main components of the alloy respectively on a underbump metallurgy (UBM) structure on a wiring/power layer (104 in Fig. 5), the device further comprising:

- the UBM structure comprising a copper layer/solder support layer (308 in Fig. 5; Col. 2, line 60), an underbump layer (UBL-304 in Fig. 5; Col. 2, line 33) having nickel as the first metal and a contact layer/electrically conductive nonwettable layer of titanium-tungsten (TiW) alloy (302 in Fig. 5; Col. 2, line 30), and
- a final structure having the solder ball/reflowed solder ball (310 in Fig. 6) being formed on the wiring/power layer

(Fig. 3-6; Col. 2, line 5- Col. 3, line 20).

Marlin fails to teach an intermetallic compound being formed between the solder bump and the UBL, the intermetallic compound including a metal that is a main component of the alloy solder and a second metal different from that of the main component.

Chan et al. teach a solder ball/UBL reflow structure where an intermetallic compound including metals such as tin (Sn) and copper (Cu) is formed after solder reflow of tin based alloy solder having tin as a main component on a metal/solder reactive layer comprising copper (38 and 42 respectively in Fig. 2 and 3; Col. 3, lines 20-56) to prevent formation of the intermetallics in the underlying layers, improve adhesion and to reduce the joint stress (Col. 3, line 10-56), the intermetallic compound/Cu-Sn including the main component/metal (Sn) of the alloy solder and the second metal such as Cu, which is different than the main component of the alloy solder (Col. 3-6).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate an intermetallic compound being formed between the solder bump and the UBL, the intermetallic compound including a metal that is a main component of the alloy solder and a second metal different from that of the main component as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 5, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 1 above, wherein Martin further teaches the tin being the main component of the SnAg alloy solder (Col. 2, line 19).

Regarding claim 9, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1 and 5 above, wherein Martin further teaches silver being the second main component of the alloy solder after tin (Col. 2, line 19).

Regarding claims 21 and 22, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 1 above, except the second metal, which is different from the first metal is allowed to form an intermetallic compound with tin and copper.

Chan et al. further teach the intermetallic compound (Sn-Cu) being formed/allowed to be formed with Sn and the second metal such as Cu (Col. 3, lines 10-56), which is different from the first metal such as nickel.

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a second metal being allowed to form an intermetallic compound with tin where second metal different from the first metal as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 29, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 1 above, wherein Martin further teaches the first metal in the UBL being nickel (304 in Fig. 5; Col. 2, line 33).

Regarding claim 30, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1 and 29 above, except the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities.

Chan et al. further teach using a Ni layer/alloy (42 in Fig. 3) as an UBL where the layer/alloy is selected to include Ni, nickel-phosphorous (NiP) having different film qualities or the combination/lamination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 31, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1 and 29 above, except the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include one or more layers/lamination of material such as Ni, Cu, NiP alloy, etc. (Col. 4, line 31) to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claims 32 and 33, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1 and 29-31 above, except the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, NiP or the combination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 49, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 1 above, wherein Martin further teaches the contact layer/electrically conductive nonwettable layer of titanium-tungsten (TiW) alloy (302 in Fig. 5 and 6) being provided between the wiring/power layer and the UBL (Col. 2, line 30).

Regarding claim 50, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1 and 49 above, wherein Martin further teaches the contact/electrically conductive nonwettable layer being TiW alloy (302 in Fig. 5 and 6; Col. 2, line 30).

**A.** Regarding claim 3, Marlin discloses a semiconductor device (100 in Fig. 5) having solder bump (310 in Fig. 5) formed of an alloy solder including tin-silver (SnAg- Col. 2, line 19), the Sn and Ag being a first and second main components of the alloy respectively on a underbump metallurgy (UBM) structure on a wiring/power layer (104 in Fig. 5), the device further comprising:

- the UBM structure comprising a copper layer/solder support layer (308 in Fig. 5; Col. 2, line 60), an underbump layer (UBL-304 in Fig. 5; Col. 2, line 33) having
- nickel as the first metal and a contact layer/electrically conductive nonwettable layer of titanium-tungsten (TiW) alloy (302 in Fig. 5; Col. 2, line 30), and
- a final structure having the solder ball/reflowed solder ball (310 in Fig. 6) being formed on the wiring/power layer

(Fig. 3-6; Col. 2, line 5- Col. 3, line 20).

Marlin fails to teach an intermetallic compound being formed between the solder bump and the UBL, the intermetallic compound including a metal that is a main component of the alloy solder and a second metal.

Chan et al. teach a solder ball/UBL reflow structure where an intermetallic compound including metals such as tin (Sn) and copper (Cu) is formed after solder reflow of tin based alloy solder having tin as a main component on a metal/solder reactive layer comprising copper (38 and 42 respectively in Fig. 2 and 3; Col. 3, lines 20-56) to prevent formation of the intermetallics in the underlying layers, improve adhesion and to reduce the joint stress (Col. 3, line 10-56), the intermetallic compound/Cu-Sn including the main component/metal (Sn) of the alloy solder and the second metal such as Cu, which is different than the main component of the alloy solder (Col. 3-6).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate an intermetallic compound being formed between the solder bump and the UBL, the intermetallic compound including a metal that is a main component of the alloy solder and a second metal as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented further diffusion of the intermetallic compound can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

**B.** Regarding claim 3, temporarily arranging a second metal layer on the underbump layer and then dissolving into the alloy solder on formation of the solder bump do not distinguish over Marlin and Chan et al., because only the final product/structure is relevant, not the process of making such as "temporarily arranging and dissolving" or

"laminating and hot pressing or fusing". Note that a "product by process" claim is directed to the product per se, no matter how actually made, In re Hirao, 190 USPQ 15 at 17 (footnote 3). See also In re Brown, 173 USPQ 685; In re Luck, 177 USPQ 523; In re Fessmann, 180 USPQ 324; In re Avery, 186 USPQ 161; In re Wertheim, 191 USPQ 90 (209 USPQ 554 does not deal with this issue); and In re Marrosi et al., 218 USPQ 289, all of which make it clear that it is the patentability of the final product per se which must be determined in a "product by process" claim, and not the patentability of the process, and that an old or obvious product produced by a new method is not patentable as a product, whether claimed in "product by process" claims or not . Note that applicant has the burden of proof in such cases, as the above case law makes clear. See also MPEP 706.03(e).

Regarding claim 7, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 3 above, wherein Martin further teaches the tin being the main component of the SnAg alloy solder (Col. 2, line 19).

Regarding claim 11, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3 and 7 above, wherein Martin further teaches silver being the second main component of the alloy solder after tin (Col. 2, line 19).

Regarding claims 25 and 26, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 3 above, except the second metal, which is different from the first metal is allowed to form an intermetallic compound with tin.

Chan et al. further teach the intermetallic compound (Sn-Cu) being formed/allowed to be formed with Sn and the second metal such as Cu, which is different from the first metal such as nickel (Col. 3, lines 10-56).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a second metal being allowed to form an intermetallic compound with tin where second metal different from the first metal as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 39, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 3 above, wherein Martin further teaches the first metal in the UBL being nickel (304 in Fig. 5; Col. 2, line 33).

Regarding claim 40, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3 and 39 above, except the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, nickel-phosphorous (NiP) having different film qualities or the combination/lamination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 41, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3 and 39 above, except the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include one or more layers/lamination of material such as Ni, Cu, NiP alloy, etc. (Col. 4, line 31) to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the

solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claims 42 and 43, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3 and 39-41 above, except the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, NiP or the combination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 53, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claim 3 above, wherein Martin further teaches the contact layer/electrically conductive nonwettable layer of titanium-Tungsten (TiW) alloy (302 in

Fig. 5 and 6) being provided between the wiring/power layer and the UBL (Col. 2, line 30).

Regarding claim 54, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3 and 53 above, wherein Martin further teaches the contact/electrically conductive nonwettable layer being TiW alloy (302 in Fig. 5 and 6; Col. 2, line 30).

Regarding claim 158, Marlin discloses a semiconductor device (100 in Fig. 5 and 6) having an electrode structure comprising:

- a solder bump (310 in Fig. 5), and
- a underbump metallurgy (UBM) structure having a plurality of metal layers including an underbump layer (UBL-304 in Fig. 5; Col. 2, line 33)

(Fig. 3-6; Col. 2, line 5- Col. 3, line 20).

Marlin fails to teach an intermetallic compound being formed between the solder bump and the UBL

Chan et al. teach a solder ball/UBL reflow structure where an intermetallic compound including metals such as tin (Sn) and copper (Cu) is formed after solder reflow of tin based alloy solder on underlying metal/phased layer comprising copper (38 and 42 respectively in Fig. 2 and 3; Col. 3, lines 10-30) to prevent formation of the

intermetallics in the underlying layers, improve adhesion and to reduce the joint stress (Col. 3, line 10-56; Col. 3-6).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate an intermetallic compound being formed between the solder bump and the UBL as taught by Chan et al. so that formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's electrode structure.

7. Claims 2, 4, 6, 8, 10, 12, 23, 24, 27, 28, 34-38, 44-48, 51, 52, 55 and 56 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046) in view of Chan et al. (US Pat. 5471092) and Darveaux et al. (US Pat. 6201305).

Regarding claim 2, Marlin discloses a semiconductor device (100 in Fig. 5) having a solder bump (310 in Fig. 5) formed of an alloy solder including tin-silver (SnAg- Col. 2, line 19), the Sn and Ag being a first and second main components of the alloy respectively on a underbump metallurgy (UBM) structure on a wiring/power layer (104 in Fig. 5), the device further comprising:

- the UBM structure comprising a copper layer/solder support layer (308 in Fig. 5; Col. 2, line 60), an underbump layer (UBL-304 in Fig. 5; Col. 2, line 33) having nickel as the first metal and a contact layer/electrically conductive nonwettable layer of titanium-tungsten (TiW) alloy (302 in Fig. 5; Col. 2, line 30), and

- a final structure having the solder ball/reflowed solder ball (310 in Fig. 6) being formed on the wiring/power layer

(Fig. 3-6; Col. 2, line 5- Col. 3, line 20).

Marlin fails to teach an alloy layer composed of a combination of intermetallic compound being formed between the solder bump and the UBL, the combination including:

a) an intermetallic compound including a metal that is a main component of the alloy solder and a second metal different from that of the main component, and

b) an intermetallic compound of the first metal included in the UBL and the metal that is the main component of the alloy solder.

a) Chan et al. teach a solder ball/UBL reflow structure where an intermetallic compound including metals such as tin (Sn) and copper (Cu) is formed after solder reflow of tin based alloy solder having tin as a main component on a metal/solder reactive layer comprising copper (38 and 42 respectively in Fig. 2 and 3; Col. 3, lines 20-56) to prevent formation of the intermetallics in the underlying layers, improve adhesion and to reduce the joint stress (Col. 3, line 10-56), the intermetallic compound/Cu-Sn including the main component/metal (Sn) of the alloy solder and the second metal such as Cu, which is different than the main component of the alloy solder (Col. 3-6).

b) Darveaux et al. teach a solder ball mounting structure (Fig. 2A/2B) having underbump layer such as nickel on a laminated pad (28 in Fig. 2A/2B; Col. 3, line 57) where an intermetallic compound such as tin-nickel (SnNi) is formed, the intermetallic compound including the metal/first metal such as nickel and the main component of the alloy of the solder ball such as tin (Col. 3, line 55- Col. 4, line 7).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a combination of intermetallic compound being formed between the solder bump and the UBL, the combination including an intermetallic compound including a metal that is a main component of the alloy solder and a second metal different from that of the main component and an intermetallic compound of the first metal included in the UBL and the metal that is the main component of the alloy solder as taught by Chan et al. and Darveaux et al. so that formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

Regarding claim 6, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 2 above, wherein Martin further teaches the tin being the main component of the SnAg alloy solder (Col. 2, line 19).

Regarding claim 10, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2 and 6 above, wherein Martin further teaches the silver being the second main component of the alloy solder after tin (Col. 2, line 19).

Regarding claims 23 and 24, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 2 above, except the second metal, which is different from the first metal is allowed to form an intermetallic compound with tin.

Chan et al. further teach the intermetallic compound (Sn-Cu) being formed/allowed to be formed with Sn and the second metal such as Cu, which is different from the first metal such as nickel (Col. 3, lines 10-56).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a second metal being allowed to form an intermetallic compound with tin where second metal different from the first metal as taught by Chan et al. so that formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claim 34, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 2 above, wherein Martin further teaches the first metal in the UBL being nickel (304 in Fig. 5; Col. 2, line 33).

Regarding claim 35, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2 and 34 above, except the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, nickel-phosphorous (NiP) having different film qualities or the combination/lamination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claim 36, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2 and 34 above, except the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include one or more layers/lamination of material such as Ni, Cu, NiP alloy, etc. (Col. 4, line 31) to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claims 37 and 38, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2 and 34-36 above, except the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, NiP or the combination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claim 51, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 2 above, wherein Martin further teaches the contact/electrically conductive nonwettable layer of titanium-tungsten (TiW) alloy (302 in Fig. 5 and 6) being provided between the wiring/power layer and the UBL (Col. 2, line 30).

Regarding claim 52, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2 and 51 above, wherein Martin further teaches the contact/electrically conductive nonwettable layer being TiW alloy (302 in Fig. 5 and 6; Col. 2, line 30).

**A.** Regarding claim 4, Marlin discloses a semiconductor device (100 in Fig. 5) having a solder bump (310 in Fig. 5) formed of an alloy solder including tin-silver (SnAg-Col. 2, line 19), the Sn and Ag being a first and second main components of the alloy respectively on a underbump metallurgy (UBM) structure on a wiring/power layer (104 in Fig. 5), the device further comprising:

- the UBM structure comprising a copper layer/solder support layer (308 in Fig. 5; Col. 2, line 60), an underbump layer (UBL-304 in Fig. 5; Col. 2, line 33) having
- nickel as the first metal and a contact layer/electrically conductive nonwettable layer of titanium-tungsten (TiW) alloy (302 in Fig. 5; Col. 2, line 30), and

- a final structure having the solder ball/reflowed solder ball (310 in Fig. 6) being formed on the wiring/power layer

(Fig. 3-6; Col. 2, line 5- Col. 3, line 20).

Marlin fails to teach an alloy layer composed of a combination of intermetallic compound being formed between the solder bump and the UBL, the combination including:

a) an intermetallic compound including a metal that is a main component of the alloy solder and a second metal, and

b) an intermetallic compound of the first metal included in the UBL and the metal that is the main component of the alloy solder.

a) Chan et al. teach a solder ball/UBL reflow structure where an intermetallic compound including metals such as tin (Sn) and copper (Cu) is formed after solder reflow of tin based alloy solder having tin as a main component on a metal/solder reactive layer comprising copper (38 and 42 respectively in Fig. 2 and 3; Col. 3, lines 20-56) to prevent formation of the intermetallics in the underlying layers, improve adhesion and to reduce the joint stress (Col. 3, line 10-56), the intermetallic compound/Cu-Sn including the main component/metal (Sn) of the alloy solder and the second metal such as Cu, which is different than the main component of the alloy solder (Col. 3-6).

b) Darveaux et al. teach a solder ball mounting structure (Fig. 2A/2B) having underbump layer such as nickel on a laminated pad (28 in Fig. 2A/2B; Col. 3, line 57) where an intermetallic compound such as tin-nickel (SnNi) is formed, the intermetallic compound including the metal/first metal such as nickel and the main component of the alloy of the solder ball such as tin (Col. 3, line 55- Col. 4, line 7).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a combination of intermetallic compound being formed between the solder bump and the UBL, the combination including an intermetallic compound including a metal that is a main component of the alloy solder and a second metal and an intermetallic compound of the first metal included in the UBL and the metal that is the main component of the alloy solder as taught by Chan et al. and Darveaux et al. so that formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Marlin's solder bump device.

**B.** Regarding claim 4, temporarily arranging a second metal layer on the underbump layer and then dissolving into the alloy solder on formation of the solder bump do not distinguish over Marlin, Chan et al. and Darveaux et al., because only the final product/structure is relevant, not the process of making such as "temporarily arranging and dissolving" or "laminating and hot pressing or fusing". Note that a "product by process" claim is directed to the product per se, no matter how actually made, In re

Hirao, 190 USPQ 15 at 17 (footnote 3). See also In re Brown, 173 USPQ 685; In re Luck, 177 USPQ 523; In re Fessmann, 180 USPQ 324; In re Avery, 186 USPQ 161; In re Wertheim, 191 USPQ 90 (209 USPQ 554 does not deal with this issue); and In re Marrosi et al., 218 USPQ 289, all of which make it clear that it is the patentability of the final product per se which must be determined in a "product by process" claim, and not the patentability of the process, and that an old or obvious product produced by a new method is not patentable as a product, whether claimed in "product by process" claims or not . Note that applicant has the burden of proof in such cases, as the above case law makes clear. See also MPEP 706.03(e).

Regarding claim 8, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 4 above, wherein Martin further teaches the tin being the main component of the SnAg alloy solder (Col. 2, line 19).

Regarding claim 12, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4 and 8 above, wherein Martin further teaches the silver being the second main component of the alloy solder after tin (Col. 2, line 19).

Regarding claims 27 and 28, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 4 above, except the second metal, which is different from the first metal is allowed to form an intermetallic compound with tin.

Chan et al. further teach the intermetallic compound (Sn-Cu) being formed/allowed to be formed with Sn and the second metal such as Cu, which is different from the first metal/nickel (Col. 3, lines 10-56).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate a second metal being allowed to form an intermetallic compound with tin where second metal different from the first metal as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claim 44, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 4 above, wherein Martin further teaches the first metal in the UBL being nickel (304 in Fig. 5; Col. 2, line 33).

Regarding claim 45, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4 and 44 above, except the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, nickel-phosphorous (NiP) having different film qualities or the combination/lamination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of the nickel and nickel alloy with different film qualities as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claim 46, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4 and 44 above, except the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include one or more layers/lamination of material such as Ni, Cu, NiP alloy, etc. (Col. 4, line 31) to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the UBL being a laminated film formed from one of nickel and nickel alloy and one of copper and copper alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the

solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claims 47 and 48, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4 and 44-46 above, except the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy.

Chan et al. further teach using a Ni alloy (42 in Fig. 3) as an UBL where the alloy is selected to include Ni, NiP or the combination of Ni and NiP to improve solderability (Col. 4, line 31).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the nickel alloy including one selected from a group consisting of nickel/vanadium (NiV), nickel/phosphorous (NiP) and nickel titanium (NiTi) alloy as taught by Chan et al. so that the formation of the intermetallics in the underlying layers can be prevented and the solderability/adhesion of the underlying metal/contact layer can be improved in Darveaux et al. and Marlin's solder bump device.

Regarding claim 55, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claim 4 above, wherein Martin further teaches the contact/electrically conductive nonwettable layer of titanium-tungsten (TiW) alloy (302 in

Fig. 5 and 6) being provided between the wiring/power layer and the UBL (Col. 2, line 30).

Regarding claim 56, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4 and 55 above, wherein Martin further teaches the contact/electrically conductive nonwettable layer being TiW alloy (302 in Fig. 5 and 6; Col. 2, line 30).

8. Claims 13 and 17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046) and Chan et al. (US Pat. 5471092) as applied to claims 1, 5 and 9 above, and further in view of Andricacos et al. (US Pat. 6224690).

Regarding claims 13 and 17, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 1, 5 and 9 above, except adding copper to the alloy solder.

Andricacos et al. teach using tin based solders having a variety of compositions including Sn-Ag solder having metals such as copper, nickel, etc. (see Table I, Col. 6) being added to achieve the desired melting range and improved wetting/flow properties (Col. 5, line 65- Col. 6, line 50).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to add copper to the alloy solder as taught by Andricacos et al. so

that the desired melting range can be achieved and the wetting/flow properties can be improved in Chan et al. and Marlin's solder bump device.

9. Claims 15 and 19 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046) and Chan et al. (US Pat. 5471092) as applied to claims 3, 7 and 11 above, and further in view of Andricacos et al. (US Pat. 6224690).

Regarding claims 15 and 19, Marlin and Chan et al. teach substantially the entire claimed structure as applied to claims 3, 7 and 11 above, except adding copper to the alloy solder.

Andricacos et al. teach using tin based solders having a variety of compositions including Sn-Ag solder having metals such as copper, nickel, etc. (see Table I; Col. 6) being added to achieve the desired melting range and improved wetting/flow properties (Col. 5, line 65- Col. 6, line 50).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to add copper to the alloy solder as taught by Andricacos et al. so that the desired melting range can be achieved and the wetting/flow properties can be improved in Chan et al. and Marlin's solder bump device.

10. Claims 14 and 18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046), Chan et al. (US Pat. 5471092) and Darveaux et al. (US

Pat. 6201305) as applied to claims 2, 6 and 10 above, and further in view of Andricacos et al. (US Pat. 6224690).

Regarding claims 14 and 18, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 2, 6 and 10 above, except adding copper to the alloy solder.

Andricacos et al. teach using tin based solders having a variety of compositions including Sn-Ag solder having metals such as copper, nickel, etc. (see Table I, Col. 6) being added to achieve the desired melting range and improved wetting/flow properties (Col. 5, line 65- Col. 6, line 50).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to add copper to the alloy solder as taught by Andricacos et al. so that the desired melting range can be achieved and the wetting/flow properties can be improved in Darveaux et al., Chan et al. and Marlin's solder bump device.

11. Claims 16 and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Marlin (US Pat. 6429046), Chan et al. (US Pat. 5471092) and Darveaux et al. (US Pat. 6201305) as applied to claims 4, 8 and 12 above, and further in view of Andricacos et al. (US Pat. 6224690).

Regarding claims 16 and 20, Marlin, Chan et al. and Darveaux et al. teach substantially the entire claimed structure as applied to claims 4, 8 and 12 above, except adding copper to the alloy solder.

Andricacos et al. teach using tin based solders having a variety of compositions including Sn-Ag solder having metals such as copper, nickel, etc. (see Table I, Col. 6) being added to achieve the desired melting range and improved wetting/flow properties (Col. 5, line 65- Col. 6, line 50).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to add copper to the alloy solder as taught by Andricacos et al. so that the desired melting range can be achieved and the wetting/flow properties can be improved in Darveaux et al., Chan et al. and Marlin's solder bump device.

### *Response to Arguments*

12. Applicant's arguments filed on 12-08-04 have been fully considered but they are not persuasive.

A. Applicant contends that a combination of Marlin, Chan et al. and Darveaux et al. do not teach an alloy layer of at least a main component of the solder and <u>a component different from the UBM layer</u>.

However, the limitations as recited in the independent claims include an intermetallic compound of a metal that is a main component of the alloy solder and a

second metal different from the metal that is the main component of the alloy solder or a combination/alloy layer of the above intermetallic compound and an intermetallic compound of the first metal included in the under bump layer and the metal that is the main component of the alloy solder. The claim limitations do not include a component which is different from the UBM layer.

B. Applicant contends that Marlin and Darveaux et al. are silent about processing conditions, bonding shape/conditions and diffusion reactions.

However, the examined claims are directed to a device/structure comprising the intermetallic, the UBM and the bump and not a method of manufacturing the device.

## *Conclusion*

13. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Nitin Parekh whose telephone number is 571-272-1663. The examiner can normally be reached on 09:00AM-05:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Eddie Lee can be reached on 571-272-1732. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9318.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

Nitin Parekh

NP

03-02-04

EDDIE LEE
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